U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE
SUBCOMMITTEE ON RESEARCH

HEARING CHARTER

Undergraduate Science, Math and Engineering Education: What's Working?

Wednesday, March 15, 2006
10:00 a.m. - Noon
2318 Rayburn House Office Building

1. Purpose

On Wednesday, March 15, 2006, the Research Subcommittee of the Committee on Science will hold a hearing to examine how colleges and universities are improving their undergraduate science, math and engineering programs and how the federal government might help encourage and guide the reform of undergraduate science, math and engineering education to improve learning and to attract more students to courses in those fields.

2. Witnesses

Dr. Elaine Seymour is the author of *Talking About Leaving: Why Undergraduates Leave the Sciences* and the former Director of Ethnography and Evaluation Research at the University of Colorado at Boulder.

Dr. Daniel L. Goroff is Vice President and Dean of Faculty at Harvey Mudd College. Prior to joining Harvey Mudd, Dr. Goroff was a professor of the practice of mathematics and the Assistant Director of the Derek Bok Center for Teaching and Learning at Harvard University. Dr. Goroff co-directs the Sloan Foundation Scientific and Engineering Workforce Project based at the National Bureau of Economic Research.

Dr. John Burris is the President of Beloit College in Wisconsin. Prior to his appointment, Dr. Burris served for eight years as director of the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts, and he served for nine years as a professor of biology at the Pennsylvania State University.

Dr. Carl Wieman is a distinguished professor of physics at the University of Colorado at Boulder and the recipient of the 2001 Nobel Prize in physics. Using his Nobel award money, Dr. Wieman has launched an effort to reform introductory physics. Dr. Wieman currently chairs the National Academy of Sciences Board on Science Education.

Ms. Margaret Collins is the Assistant Dean of Science, Business and Computer Technology at Moraine Valley Community College in the southwest suburbs of Chicago, Illinois.

3. Overarching Questions

- What are the obstacles to recruiting and retaining science, math and engineering majors and what actions are being taken to overcome them?
- What are the obstacles to implementing reforms in undergraduate science, math and engineering education?
- What role have federal agencies, particularly the National Science Foundation (NSF), played in improving undergraduate science, math and engineering education? What more should federal agencies be doing in this area?

4. Background

Undergraduate education is the first step toward a career in science, engineering, or mathematics; it is the primary source of education and training for technical workers; and, it is often the last time non-majors will take a class in science and mathematics. Yet the undergraduate level is also the point at which many students who begin college interested in science, math and engineering decide to move out of these fields.

U.S. Competitiveness

Over the past several years, a number of industry and policy organizations have released reports calling for increased investment in science and engineering research and increased production of students with degrees in scientific and technical fields, including the Council on Competitiveness, the National Academy of Sciences, AeA (formerly the American Electronics Association), the Business Roundtable, Electronic Industries Alliance, National Association of Manufacturers, TechNet, and the Association of American Universities. While the companies and the industry sectors represented by these organizations varies widely, one general recommendation was common to all of the reports: the federal government needs to strengthen and re-energize investments in science and engineering education.

The National Academy of Sciences, in its report *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* recommended establishing 25,000 new four-year scholarships to attract more U.S. undergraduate students to science, technology, engineering and mathematics (STEM) fields, and it encouraged research universities to offer two-year part-time master's degrees that focus on science and mathematics content and pedagogy. Similarly, the Business Roundtable and other industry groups have recommended creating scholarships and loan forgiveness programs for students who pursue degrees in STEM fields and emphasize the need to improve recruitment and retention of STEM majors at undergraduate institutions.

Challenges in Undergraduate Education

The U.S. contains a large and diverse group of institutions of higher education. While American graduate education in STEM fields is generally considered to be the best in the world, the quality of students' undergraduate experiences can be hindered by insufficient pre-college preparation, poor college instruction, and high rates of attrition among potential STEM majors.

College Readiness

Recent results of national assessments of high school science and mathematics suggest that few students graduate with the mathematical or analytical skills necessary for college-level mathematics or science. According to the National Center for Education Statistics, all of the Nation's community colleges and most four-year institutions offer remedial courses in reading, writing and mathematics. In addition, Freshman Norms[1] trend data also reveals that more than 20 percent of first year college students intending to undertake a science or engineering major and 10 percent of those in the mathematics report that they believe that they will need remedial coursework.

Federal education efforts undertaken in the context of the 2001 *No Child Left Behind Act* are providing greater focus on math and science, with annual assessments in mathematics occurring now and assessments in science starting in 2007. But many education experts point out that, until the quality of STEM education at the elementary and secondary levels improves, some students will continue to lack the necessary preparation for undergraduate education in STEM fields.

Attrition

According to the 2005 Survey of the American Freshman, the longest running survey of student attitudes and plans for college, approximately one-third of all incoming freshmen have traditionally contemplated a major in a science and engineering field, with most intending to major in a field of natural or social science and a smaller percentage selecting mathematics, the computer sciences, or engineering. Yet, half of all students who begin in the physical or biological sciences and 60 percent of those in mathematics will drop out of these fields by their senior year, compared with the 30 percent drop out rate in the humanities and social sciences. The attrition rates are even higher for underrepresented minorities.

In research for *Talking About Leaving: Why Undergraduates Leave the Sciences*, the authors determined that the most common reasons offered for switching out of a science major included a lack or loss of interest in science, belief that another major was more interesting or offered a better education, poor science teaching, and an overwhelming curriculum. This study reinforced earlier anecdotal evidence that suggested that the sciences did a poor job of retaining young talent. In addition, and contrary to conventional wisdom that suggested that the students who switched out of science majors were somehow less academically able, the researchers discovered that those who left were among the most qualified students[2] who had initially expressed the greatest interest in pursuing a STEM major.

Many researchers, including Stanford economist Paul Romer, believe that undergraduate education actively discourages more students from majoring in STEM fields or taking additional science or mathematics courses. Many colleges and universities have institutionalized a process partially designed to "weed out" all but the most committed students. While some amount of switching is appropriate, and few would disagree about the selective nature of many science and engineering programs, this "science-for-the few" approach seems to reduce the number of STEM

[1] Higher Education Research Institute (HERI), University of California at Los Angeles, *The American Freshman: National Norms*, 2001.

[2] Most qualified students were identified by high math SAT scores (at least 650) and their high school preparation.

majors unnecessarily and may be particularly alienating to women and underrepresented minorities.

According to *Talking About Leaving*, most of the concerns of those who dropped out of science majors were shared by those who continued in science, math and engineering. The chief complaint, cited by 83 percent of all respondents, was poor teaching. In the university setting, the traditional reward structure for faculty often favors the conduct of research over teaching. This can create an environment where faculty enthusiasm for and commitment to teaching is limited. As a result, undergraduates who take science and mathematics at many colleges and universities often find themselves in large lecture halls, taught by junior faculty. Student interaction with prominent research scientists ranges may be limited, and many of the junior faculty and teaching assistants may not be trained or motivated to teach well. Some may even be discouraged from expressing an interest in teaching or mentoring undergraduates.

In addition to these problems with courses for STEM majors, many introductory courses for non-majors fail to foster scientific understanding among the non-science majors. Without a broader context, many students never understand the process of science or the content of the subject matter. According to research in the *Journal of College Science Teaching*, this narrow approach to STEM courses alienates non-majors who graduate with the perception that science is difficult, boring, and irrelevant to their everyday interests.

Undergraduate Reforms

Individual faculty, departments, professional societies, and institutions of higher education are increasingly involved in reform efforts to enhance STEM curriculum and improve undergraduate teaching. Many of these reforms include the reexamination and restructuring of introductory and lower level courses to benefit both those who go on to careers as STEM professionals and teachers, as well as the vast majority who do not plan to become STEM majors.

The new goal of "science-for-all" seeks to provide opportunities for students of all backgrounds and interests to study science as practiced by scientists. Some faculty are trying to supplement lectures with discussion, small group work on a question or problem, and other short activities that are designed to break up the session and engage students in understanding and applying class materials. The new approaches attempt to present students with a coherent structure of general concepts that are established by experiment and to lead students to use problem-solving approaches that are applicable to a wide variety of situations – something that is typically experienced only in upper level courses. In addition, some colleges and universities are reexamining their incentive structures to encourage faculty to teach or mentor undergraduates and to ensure that introductory courses are taught by experienced faculty.

Federal Support for Undergraduate Education

The National Science Foundation (NSF) has historically been the primary federal agency to provide support for undergraduate education in STEM fields. In 1987, the National Science Board released a report on *Undergraduate Science, Mathematics and Engineering Education*, better known as the "Neal Report"[3] after its chairman, Homer Neal of the University of

[3] *Undergraduate Science, Mathematics and Engineering Education*, National Science Board, 1986.

Michigan. The Neal Report urged NSF to increase its investment in undergraduate education, and particularly to offer programs to involve undergraduate faculty and students in research activities.

NSF Undergraduate Education
NSF primarily funds undergraduate STEM education programs through its Division of Undergraduate Education (DUE). Funding for DUE programs at NSF has declined each year since fiscal year 2004 (FY04). FY06 funding for DUE totaled $211 million, and the FY07 budget request is $196 million.

Several NSF programs in undergraduate education were created or expanded by the *National Science Foundation Authorization Act of 2002*. This Act established the Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) to increase the number of U.S. students majoring in STEM fields. Specifically, STEP provides funding and rewards to colleges and universities that develop creative and effective recruitment and retention strategies that bring more students into science, mathematics, and engineering programs. The FY06 appropriation for STEP was $25.5 million; the request for FY07 is $26 million.

The Act also strengthened and expanded the Advanced Technological Education (ATE) program, which aims to expand the pool of skilled technicians in the U.S. by providing support to community colleges. Specifically, ATE supports curriculum development; professional development of college faculty and secondary school teachers; and efforts to align curricula to allow easy transition from high school to community colleges and community colleges to four year colleges and universities. The FY06 appropriation for ATE was $45 million; the request for FY07 is $46 million.

A third major program in DUE is the Course, Curriculum and Laboratory Improvement Program (CCLI). This program supports efforts to create new learning materials and teaching strategies, develop faculty expertise, implement educational innovations, assess learning and evaluate innovations, and conduct research on STEM teaching and learning. Funding for this program has declined in the past two years, falling from $94 million in FY05 to $88 million in FY06. The FY07 request is $86 million.

Other Undergraduate Support at NSF
In addition to the DUE programs described above, the Division of Human Resource Development (HRD) at NSF supports programs to increase the participation of underrepresented students in science at all levels. Undergraduate programs in HRD include the Louis Stokes Alliances for Minority Participation Program ($35 million in FY06, $40 million requested in FY07), the Historically Black Colleges and Universities Undergraduate Program ($25 million in FY06, $30 million requested in FY07), and the Tribal Colleges and Universities Program ($9 million in FY06, $12 million requested in FY07).

Through its Research Experiences for Undergraduates program, which is run through NSF's research directorates, NSF supports active participation by undergraduates in research funded by NSF. Under this program, undergraduate students are associated with a specific research project, where they work closely with faculty and other researchers, and are granted stipends and, in

many cases, assistance with housing and travel. (The research work can take place at a student's home institution or elsewhere, usually during the summer.)

Support for Undergraduate STEM Education at Other Agencies
While the U.S. Department of Education (ED) supports programs to strengthen undergraduate education, most are targeted to particular institutions and most are not STEM specific. For instance, ED supports several programs to build the capacity of Historically Black Colleges and Universities, Tribal Colleges, and other minority serving institutions, but funds may be used for a variety of purposes so it is difficult to determine what, if any, portion funds STEM reform. Outside NSF and ED, federal science agencies, including the U.S. Department of Energy and the National Aeronautics and Space Administration, provide opportunity for undergraduates to participate in research experiences at their facilities.

Legislation
While this hearing is not designed to focus on any specific legislation, it is worth noting that several bills have been introduced to strengthen STEM education in response to the various reports and commissions on U.S. competitiveness. Most of these bills seek to address the undergraduate recruitment challenge. Specifically, S. 2109 and H.R. 4654, the National Innovation Act, expand NSF's STEM Talent Expansion Program from $35 million in FY07 to $150 million in FY11. S. 2198, Protecting America's Competitive Edge (PACE) Act, awards scholarships to students majoring in STEM education who concurrently pursue their teacher certification, and H.R. 4434, introduced by Congressman Bart Gordon, implements the recommendations of the National Academy of Sciences' *Rising Above the Gathering Storm* report. S. 2197, PACE-Energy, also includes undergraduate education provisions, such as a scholarship program for students in STEM fields and the creation of a part-time, three-year master's degree in math and science for teachers, but the programs are administered by the Department of Energy – not NSF.

5. Questions for Witnesses

The panelists were asked to address the following questions in their testimony before the Committee:

Dr. Elaine Seymour:
- What has your research shown about why potential science majors drop out of undergraduate science programs?
- What changes in undergraduate science education could prevent capable students from leaving science disciplines and perhaps also attract students initially not interested in science? What are the principle obstacles to implementing these changes?
- What role have federal agencies, particularly the National Science Foundation, played in improving undergraduate science education? What more should federal agencies be doing in this area?

Dr. Daniel L. Goroff:
- What obstacles have you encountered at Harvey Mudd College and Harvard University in

recruiting and retaining STEM majors and what actions have you taken to overcome them? How are you measuring the effectiveness of those actions?
- What are the obstacles to implementing similar improvements at other institutions of higher education?
- What role have federal agencies, particularly the National Science Foundation (NSF), played in improving undergraduate STEM education? What more should federal agencies be doing in this area?

Dr. John Burris:
- What obstacles have you encountered at Beloit College in recruiting and retaining STEM majors and what actions has Beloit College taken to overcome them? How are you measuring the effectiveness of those actions?
- What are the obstacles to implementing similar improvements at other institutions of higher education?
- What role have federal agencies, particularly the National Science Foundation (NSF), played in improving undergraduate STEM education? What more should federal agencies be doing in this area?

Dr. Carl Wieman:
- What obstacles have you encountered at the University of Colorado in recruiting and retaining physics majors and what actions have you taken to overcome them? How are you measuring the effectiveness of those actions?
- How would your experience apply to other institutions of higher education or to other fields of science?
- What role have federal agencies, particularly the National Science Foundation (NSF), played in improving undergraduate STEM education? What more should federal agencies be doing in this area?

Ms. Margaret Collins:
- What obstacles have you encountered at Moraine Valley Community College in recruiting and retaining STEM majors? What actions has Moraine Valley Community College taken to overcome them? How are you measuring the effectiveness of those actions?
- What are the obstacles to implementing similar improvements at other institutions of higher education?
- What role have federal agencies, particularly the National Science Foundation, played in improving undergraduate STEM education? What more should federal agencies be doing in this area?